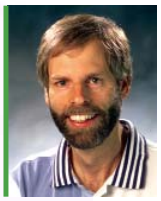
Hydraulic Power Unit for Hydrostatic Bearings



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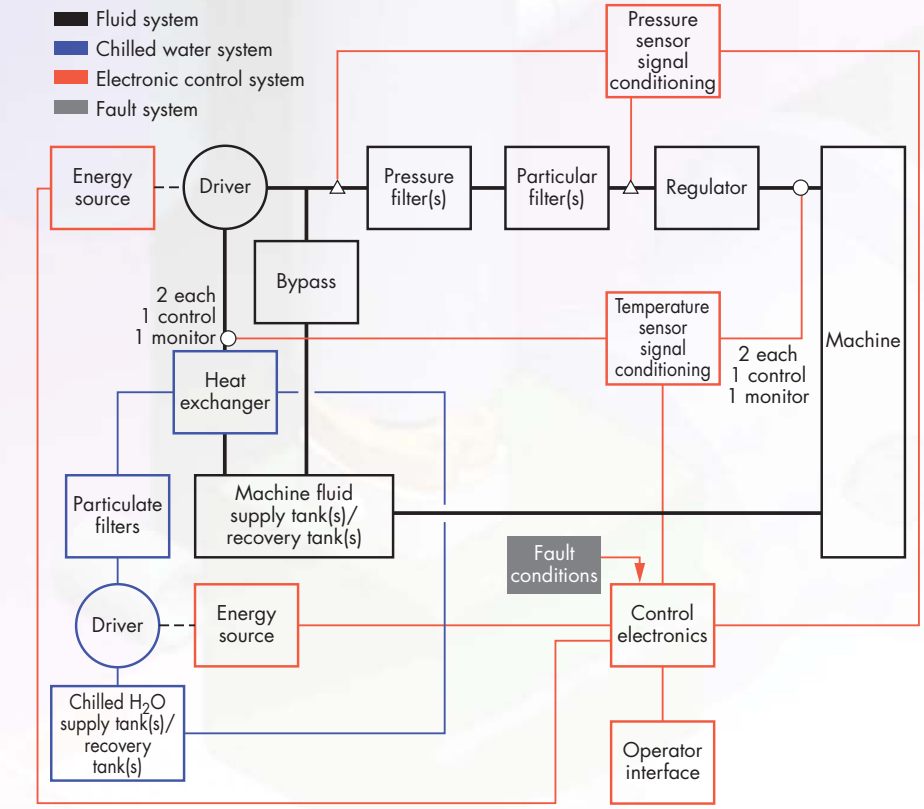
This project is focused on two hydraulic power units for hydrostatic (oil) bearings. The first unit powers the hydrostatic bearings of a precision machine tool axis; the second powers those of a precision machine tool spindle. In this project, a precision machine tool is defined as a machine capable of nanometer position control with less than a tenth of a micron accuracy throughout the work volume of the machine. The two hydraulic units cover a range of thermal heat loads and bearing flowrates to maintain a high degree of stable pressure and temperature control. Key factors addressed are the refinement of computer models that aid in the construction of hydrostatic fluid pressure and temperature control systems.

Figure 1. Schematic of system. (The regulator was not used).



Project Goals

Repeatability is an important characteristic of a precision machine tool. By investigating the sources of non-repeatability, it is possible to quantify and control these sources. A machine expands and contracts with temperature. A new LLNL machine, the Precision Optical Grinder and Lathe (POGAL) has an approximately 350-×-350-mm work volume and an accuracy of 10 nm RMS. The temperature of this machine must be held to mili-degree levels to maintain machine repeatability within acceptable limits.

Pressure control is also important. A machine axis will move due to oil pressure fluctuations of the slide bearings. Many older LLNL precision machines use an air-over-oil dual accumulator control system. The pressure fluctuations in this type of system are low, but can be problematic when the system switches from the empty accumulator to the full accumulator as a pressure spike momentarily occurs.

The project goals were to model and build a highly stable and integrated pressure and temperature control system for use on precision machines. The model helped size components for two systems covering a range of hydrostatic bearing requirements. In addition, the model is available for sizing any new system.

Relevance to LLNL Mission

LLNL has a long history of contributions to the field of precision engineering.

Some of our machines support target and fixture fabrication for NIF and weapons programs. They can fabricate precision optics by diamond turning. The continuing investment in the future of machines such as the POGAL will help the Laboratory be prepared for the expanding field of x-ray optics. This project supports the ability to build new precision machines and to modernize older ones.

FY2004 Accomplishments and Results

Figures 1 to 3 illustrate our system. In FY2004, models have been fine-tuned for the pressure control system of the hydrostatic bearings and for the heat exchanger characteristics over a range of fluid flowrates and viscosities. Two pressure and temperature control systems cover a range of precision machine needs, from the low-heat-load requirements of the slide bearings to the dynamic higher-heat-load demands of a spindle bearing.

The electronic control system looks industrialized, but is actually a sophisticated dual-loop control system capable of temperature and oil pressure control. The system works to maintain pressure by using a variable frequency drive motor/pump in a PID loop to control pressure. Temperature control is done in a similar manner with dual PID control loops, using either a variable frequency drive motor/pump or a proportional valve to vary the flow rate of chilled water through the heat exchanger. An operator interface to the PLC has been created via LabView, allowing temperature and pressure data to be observed and trended. In addition, LabView provides a data communication interface to the machine tool controller. Modernized high-stability thermistor signal conditioning electronics for temperature sensing has been completed.

The system includes a specially selected pump that minimizes pressure fluctuations, and an accumulator/restrictor combination similar to an electronic low-pass filter that further reduces any other pressure variations. All system parts have arrived on site and we plan to complete the assembly of both systems.

Figure 2. Electrical/electronic control panel.

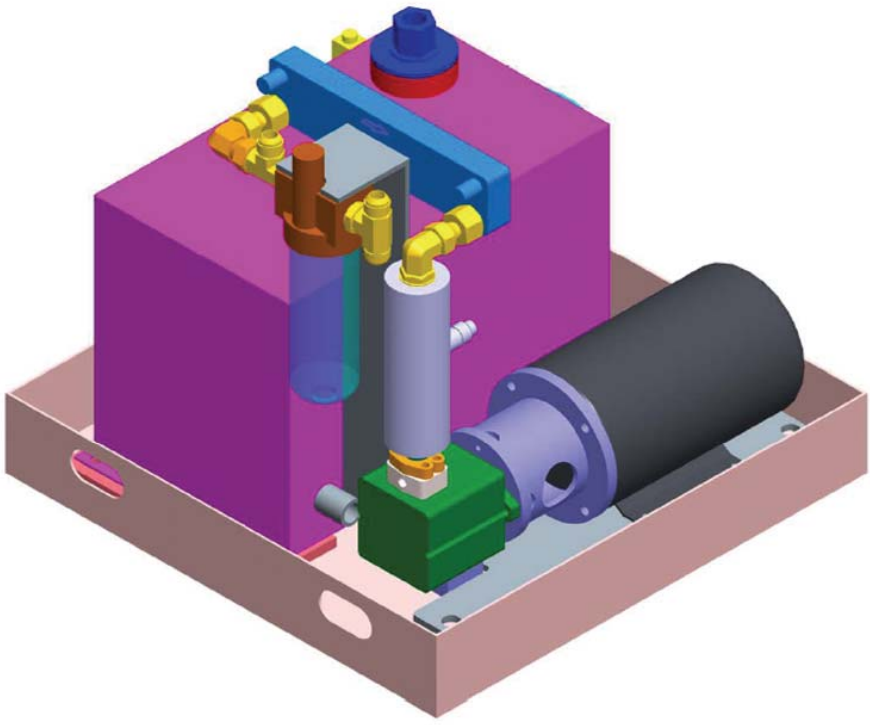


Figure 3. Hydraulic system mechanical layout.